

**NIMS detects both reflected sunlight and thermal emission
(0.7 to 5.2 microns)**

NIMS OBSERVATION OBJECTIVES:

- **Reflected sunlight:**

- Global distribution of SO₂ on surface**
 - Local distribution of SO₂ near hot spots and plumes**
 - Detection of SO₂ in volcanic plumes**
 - Detection of new species**

- **Thermal emission:**

- Global distribution of hot spots**
 - Temporal variations of volcanic activity**
 - Local distribution of thermal emission within hot spots**
 - Detection of thermal emission from plumes**

NIMS SCIENCE OBJECTIVES:

- **Mechanism of SO₂ deposition**

**Relationship between SO₂ distribution and
active plumes
thermal emission
surface colors**

- **Eruption mechanisms and styles, temporal variations**

**Comparisons with terrestrial volcanism
Implications of global distribution to tidal heating mechanism
Temperatures and composition of lavas
Relationship between hot spots, surface colors, and plumes**

OUTLINE

1. SUMMARY OF NIMS RESULTS FROM GALILEO AND GEM TOUR:

- **111 global/part global observations of Io (G1-C22)
(June 1996-August 1999)
Spatial resolutions from 65 to 800 km/pixel**
- **Global distribution of volcanic activity and SO₂**
- **Temporal variations of volcanic activity**
- **Correlations between volcanic activity, surface colors, and plumes
(with SSI)**
- **Detection of very high temperatures (with SSI)**

INITIAL RESULTS FROM THE CLOSE FLY-BYS (I24 AND I25):

- **17 observations in I24 (0.5 to 105 km/NIMS pixel)
4 observations returned in I25 (9 to 20 km/NIMS pixel)**
- **Local distribution of temperatures in volcanic centers**
- **Local distribution of SO₂ and correlations with surface colors
(with SSI)**
- **Detection of smaller, fainter hot spots not seen in low resolution
observations from the Galileo and GEM tour**
- **Correlation between local temperatures, SO₂ distribution and
plume activity at Prometheus**

NIMS I24 AND I25 HIGHLIGHTS:

24 LOKI (2 km/pixel): thermal map, nightside

24 TOHIL (5 km/ pixel): SO₂ map, no thermal

25 CULANN (11 km/pixel): SO₂ map, no thermal

24 AMIRANI (12 km/pixel): SO₂ map, thermal map

24 PROMETHEUS (2 km/pixel): thermal map

24 PROMETHEUS (7 km/pixel): thermal map

24 PROMETHEUS REGION (23 km/pixel): SO₂ map, thermal map

25 PROMETHEUS REGION (20 km/pixel): SO₂ map, thermal map

25 GIANTS (9 km/pixel): minimum temperature

1. ACTIVE VOLCANIC CENTERS: GLOBAL DISTRIBUTION AND TEMPORAL VARIATIONS (Lopes-Gautier et al. 1999)

- **Detections of hot spots up to C22:**

81 active volcanic centers known, 23 others suspected

- **Temporal activity:**

30 hot spots known to be persistent over periods > 1 year

- **Thermal emission and persistent hot spots concentrated at low latitudes, favoring tidal dissipation in the asthenosphere**

- **Temperatures and variations in power output:**

Ultramafic-type temperature detected at Pillan (C9): 1800K

Power output of many hot spots fairly constant

- **Correlations with surface colors and plumes:**

Red and black materials are generally associated with hot spots

Plumes (except Ra and Masubi) coincide with persistent hot spots

13/30 (43%) persistent hot spots have plumes or plume deposits

15/30 (50%) persistent hot spots are associated with red deposits

2. IMPLICATIONS FOR VOLCANIC SYSTEMS

PERSISTENT HOT SPOTS:

- **Magma supply rate balanced by magma output rate**
- **Possibly analogous to "open system" volcanism on Earth
e.g. Stromboli, Kilauea**
- **Francis et al. [Nature, 1993]: Persistent volcanism
steady supply of mantle-derived magma, or
convective exchange of magma in chamber with deeper reservoirs**

SPORADIC HOT SPOTS: SOURCES OF OUTBURSTS?

- **Only 2-3 well-constrained outburst locations (Arusha, 9908A, Loki?)**
- **Loki (1990 outburst) is persistent hot spot, Arusha and 9908A are not**
- **Outbursts may represent a different style of activity than that seen at
persistent hot spots**
- **Magma chamber is suddenly emptied and activity may die for long
periods of time while chamber is being replenished**

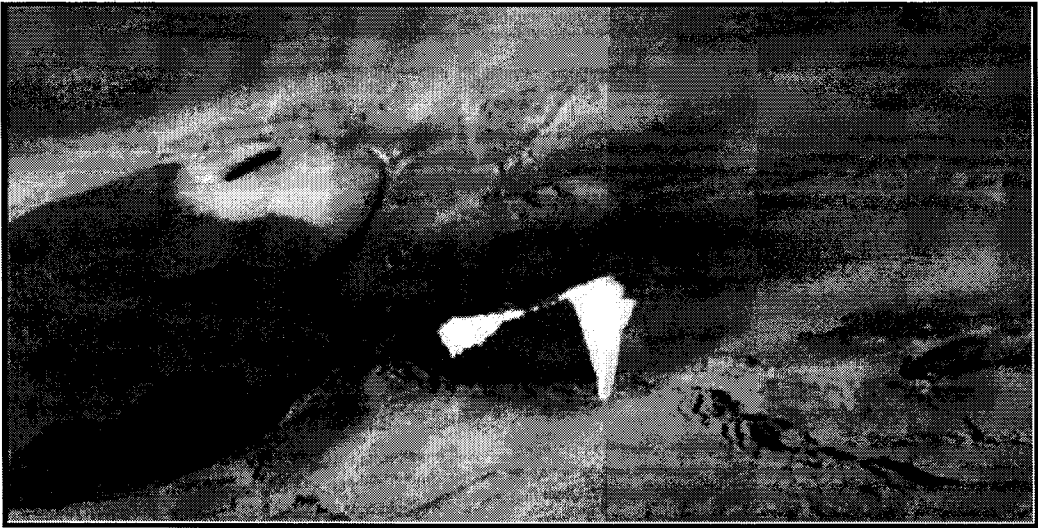
RESULTS FROM GALILEO AND GEM TOUR:

3. GLOBAL DISTRIBUTION OF SO₂ (Doute et al. 1999)

- **SO₂ frost present everywhere**
- **Concentrated at medium latitudes, although plumes erupt near equator**
- **Most extended and richest area is located south of Pele, Pillan, and Marduk, all plume sites**
- **Longitudes of other areas rich in SO₂ coincide with plume sites**

 NASA'S PLANETARY PHOTOJOURNAL
CATALOG PAGE

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Image Title: Nea
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Catalog #: PIA
Target Name: Io
Is a satellite of: Jupi
Mission: Gali
Spacecraft/Mission: Gali
Nea
Instrument: Ma
Spe
Product Size: 800
line
Produced By: JPL
Producer ID: MR
Creation Date: 1999
Primary Data Set: Gali
Full-Res TIFF: PIA
kby



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JPEG ▾

 format (may be reduced in size for conversion).
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Original Caption Released with Image:

A very active volcano on Jupiter's moon Io, probably composed of erupting lava fountains, was seen by the Near-Infrared Mapping Spectrometer onboard NASA's Galileo spacecraft. The volcano is shown here (in color) superimposed on the camera image that was taken almost simultaneously. The spectrometer observation covers the eastern part of the active caldera and shows a hot, active region (in red). The blue color represents cool terrain surrounding the caldera. The spectrometer instrument can detect heat from active volcanic regions by imaging them in near-infrared light (0.7 to 5.2 micron wavelengths). Determining temperatures of the hot region has been difficult because the lava is so hot that it exceeded the upper limit that the instrument could measure. The lava is at least 700 degrees Celsius 1,292 degrees F), but the hotter regions within the caldera probably exceed 1,200 Celsius (2,192 degrees F)

The Jet Propulsion Laboratory, Pasadena, CA manages the Galileo mission for NASA's Office of Space Science, Washington, DC. JPL is a division of the California Institute of Technology, Pasadena, CA.

This image and other images and data received from Galileo are posted on the Galileo mission home page at <http://galileo.jpl.nasa.gov>. Background information and educational context for the images can be found at <http://galileo.jpl.nasa.gov/images/io/ioimages.html>.

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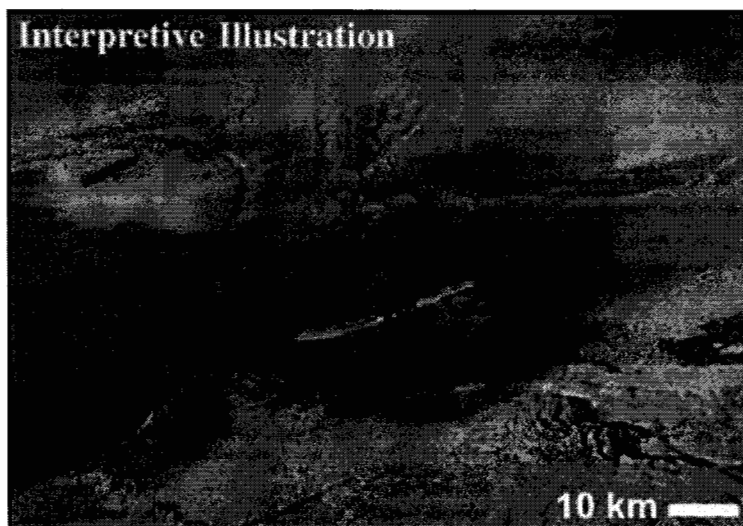

**NASA'S PLANETARY PHOTOJOURNAL
CATALOG PAGE**
Interpretive Illustration

Image Title: **Interpreted Lava
Fountains on Io**

Catalog #: **PIA02525**

Target Name: **Io**

Is a satellite of: **Jupiter**

Mission: **Galileo**

Spacecraft/Mission: **Galileo Orbiter**

Instrument: **Solid State Imaging**

Product Size: **717 samples x 653 lines**

Produced By: **Arizona State
University**

Producer ID: **MRPS95796**

Creation Date: **1999-12-17**

Primary Data Set: **Galileo EDRs**

Full-Res TIFF: **PIA02525.tif (1
Mbytes)**

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Original Caption Released with Image:

This mosaic of images collected by NASA's Galileo spacecraft on Thanksgiving Day, November 25, 1999 shows a fountain of lava spewing above the surface of Jupiter's moon Io.

In the original images, the active lava was hot enough to cause what the camera team describes as "bleeding" in Galileo's camera, caused when the camera's detector is so overloaded by the brightness of the target that electrons spill down across the detector. This showed up as a white blur in the original images. With the aid of computers, the whited-out area has been reconstructed to appear as it might without the 'bleeding.'

Most of the hot material is distributed along a wavy line which is interpreted to be hot lava shooting more than 1.5 kilometers- (1-mile) high out of a long crack, or fissure, on the surface. There also appear to be additional hot areas below this line, suggesting that hot lava is flowing away from the fissure. Initial estimates of the lava temperature indicate that it is well above 1,000 Kelvin (1,300 Fahrenheit) and might even be hotter than 1,600 Kelvin (2,400 Fahrenheit).

These images were targeted to provide the first close-up view of a chain of huge calderas (large volcanic collapse pits). These calderas are some of the largest on Io and they dwarf other calderas across the solar system. At 290 by 100 kilometers (180 by 60 miles), this chain of calderas covers an area seven times larger than the largest caldera on the Earth. The new images show the complex nature of this giant caldera on Io, with smaller collapses occurring within the elongated caldera.

Also of great interest is the flat-topped mesa on the right. The scalloped margins are typical of a process geologists call 'sapping,' which occurs when erosion is caused by a fluid escaping from the base of a cliff. On Earth, such sapping features are caused by springs of groundwater. Similar features on Mars are one of the key pieces of evidence for past water on the Martian surface. However, on Io, the liquid is presumed to be pressurized sulfur dioxide. The liquid sulfur dioxide should change to a gas almost instantaneously upon reaching the near-vacuum of Io's surface, blasting away material at the base of the cliff. The sulfur dioxide gas eventually freezes out on the surface of Io in the form of a frost. As the frost is buried by later deposits, it can be heated and pressurized until it becomes a liquid. This liquid then flows out of the ground, completing Io's version of the 'water cycle.'

North is to the upper left of the picture and the Sun illuminates the surface from the lower left. The image, centered at 61.1 degrees latitude and 119.4 degrees longitude, covers an area approximately 300 by 75 kilometers (190-by-47 miles). The resolution is 185 meters (610 feet) per picture element. The image was taken at a range of 17,000 kilometers (11,000 miles) by Galileo's onboard camera.

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Io's Prometheus Regions

Image Title: **as Viewed by Galileo
NIMS**

Catalog #: **PIA02515**

Target Name: **Io**

Is a satellite of: **Jupiter**

Mission: **Galileo**

Spacecraft/Mission: **Galileo Orbiter**

Instrument: **Near Infrared Mapping
Spectrometer**

Product Size: **1157 samples x 841 lines**

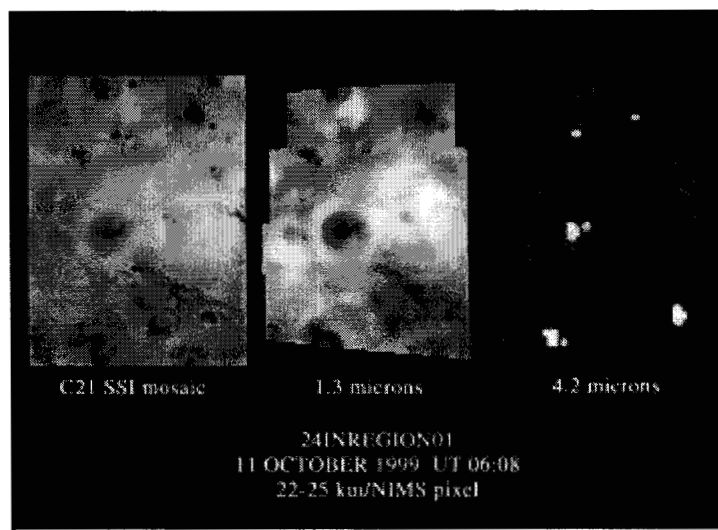
Produced By: **JPL**

Producer ID: **MRPS95572,P50691**

Creation Date: **1999-11-19**

Primary Data Set: **Galileo EDRs**

Full-Res TIFF: **PIA02515.tif (849 kbytes)**



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Original Caption Released with Image:

This image shows the region around the Prometheus volcano on Jupiter's moon Io. It was observed by the near-infrared mapping spectrometer on NASA's Galileo spacecraft as it was flying away from a close approach to Io. The area shown is about 1.6 million square kilometers (about 600,000 square miles), roughly the size of the "four corner states" (Arizona, New Mexico, Utah, and Colorado).

The spectrometer instrument detects heat emitted by objects that is not visible to the naked eye. The image on the left was taken by Galileo's camera in visible wavelengths; it shows the context for the center and right images. The center and right images show spectrometer data at wavelengths of 1.3 and 4.2 microns respectively. The spectrometer can determine surface composition by measuring the spectrum of reflected sunlight, and can measure thermal emission from Io's hot lava.

Prometheus is seen near the center of the three images. The image in the center, taken by the spectrometer at 1.3 microns, shows variations in light and dark surface materials, which result from variations in composition. The spectrometer thermal map (image on right) at 4.2 microns shows where the most heat is being produced from active volcanoes on the surface. The bright colors are used to indicate hot areas. Ten active volcanic regions (hot spots) are seen in this image. Four faint hot spots near the top of the image were not known to be active volcanoes before this image was acquired. All the hot spots correspond to dark areas in the visible wavelengths. This indicates that where the camera shows dark regions on Io, the infrared observations reveal that those regions contain hot lava.

A distinct, dark ring can be seen clearly in the spectrometer's 4.2-micron map. The ring indicates a higher local concentration of sulfur dioxide, which appears dark at this wavelength. The dark ring is slightly larger in diameter than the bright ring that can be seen in the visible light camera image and the spectrometer's 1.3-micron image. This contradicts a previous belief that regions rich in sulfur dioxide on Io's surface appear white at visible wavelengths. The Prometheus ring is believed to be composed of fallout from the Prometheus volcanic plume. It is possible that both sulfur and sulfur dioxide are present in the plume, and that the bright white ring represents mostly sulfur deposits. Because sulfur dioxide is more volatile than sulfur, it may not condense and stick to the surface as close to the volcanic vent as sulfur does.

Launched in October 1989, Galileo entered orbit around Jupiter on December 7, 1995 on a mission to study the giant planet, its largest moons and its magnetic environment. JPL manages the mission for NASA's Office of Space Science, Washington, DC. JPL is a division of the California Institute of Technology, Pasadena, CA.

This image and other images and data received from Galileo are posted on the World Wide Web, on the Galileo mission home page at <http://galileo.jpl.nasa.gov>. Background information and educational context for the images can be found at <http://galileo.jpl.nasa.gov/images/io/ioimages.html>.

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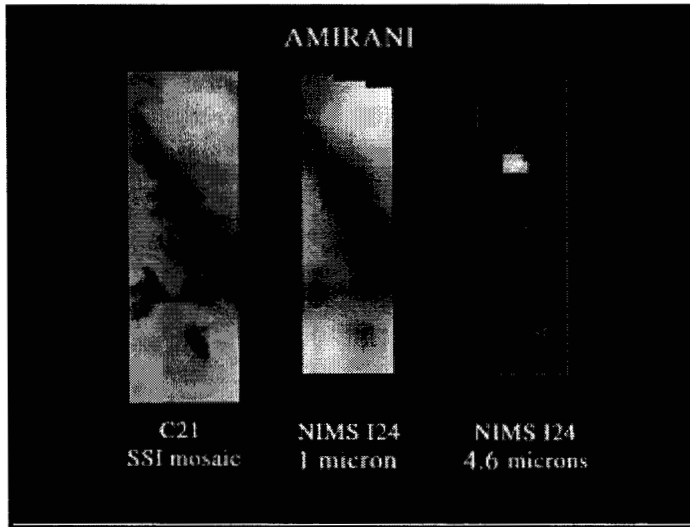


Image Title: **Galileo NIMS Observes
Amirani**

Catalog #: **PIA02516**

Target Name: **Io**

Is a satellite of: **Jupiter**

Mission: **Galileo**

Spacecraft/Mission: **Galileo Orbiter**

Instrument: **Near Infrared Mapping
Spectrometer**

Product Size: **841 samples x 631 lines**

Produced By: **JPL**

Producer ID: **MRPS95573,P50692**

Creation Date: **1999-11-19**

Primary Data Set: **Galileo EDRs**

Full-Res TIFF: **PIA02516.tif (267 kbytes)**

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Original Caption Released with Image:

This image is the highest-resolution thermal, or heat image, ever made of Amirani, a large volcano on Jupiter's moon Io. It was taken on October 10, 1999, by the near-infrared mapping spectrometer onboard NASA's Galileo spacecraft. Amirani is on the side of Io that permanently faces away from Jupiter.

This image of Amirani was taken at a distance of less than 25,000 kilometers (16,000 miles). The picture scale is approximately 6.5 kilometers (4 miles) per spectrometer pixel. The center and right images show views of Amirani as seen by the spectrometer at two wavelengths, 1.0 and 4.6 microns. These images can be compared with a visible wavelength image (on the left) of the same area obtained by Galileo's camera during a previous orbit. The visible light image shows extensive lava flows and a dark-floored caldera with associated bright red deposits of material fed from the volcano. The spectrometer observation was made in daylight. The center image, taken at a wavelength of 1 micron, shows light and dark areas on the surface that can be used to line up the spectrometer data with the camera image. The image on the right shows the same area at a wavelength of 4.6 microns, which reveals the thermal emission from three separate volcanic areas. The locations of these three "hot spots" correspond to the darkest features in the camera image, reinforcing a previously held belief by Galileo scientists that there is a correlation between the dark areas and the hot spots.

The three spectrometer hot spots are located at the eastern edge of the caldera at the bottom of the camera image, and two locations along the massive Amirani flows. These are most likely active lava flows on the surface.

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